Predictors of Smoking Initiation and Cessation Among Childhood Cancer Survivors: A Report From the Childhood Cancer Survivor Study

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Purpose: To examine the determinants of smoking behavior among participants in the Childhood Cancer Survivors Study (CCSS).

Methods: This retrospective cohort survey study was conducted among 9,709 childhood cancer survivors. Main outcomes included smoking initiation and cessation.

Results: Twenty-eight percent of patients reported ever smoking and 17% reported being current smokers. Standardized to United States population rates, the observed to expected (O/E) ratios and corresponding 95% confidence limits (95% CL) of cigarette smoking were 0.72 (95% CL, 0.69, 0.75) among all survivors and 0.71 (95% CL, 0.68 to 0.74) and 0.81 (95% CL, 0.70, 0.93) among whites and nonwhites, respectively. Significantly lower O/E ratios were present among both males (O/E, 0.73) and females (O/E, 0.70). Factors independently associated with a statistically significant relative risk of smoking initiation included older age at cancer diagnosis, lower household income, less education, not having had pulmonary-related cancer treatment, and not having had brain radiation. Blacks were less likely to start smoking. Survivors who smoked were significantly more likely to quit (O/E, 1.22; 95% CL, 1.15, 1.30). Among ever-smokers, factors associated with the likelihood of being a current smoker included age less than 13 years at smoking initiation, less education, and having had brain radiation; those age less than 3 years at cancer diagnosis were significantly more likely to be ex-smokers.

Conclusions: Although survivors in the CCSS cohort seem to be smoking at rates below the general population, interventions are needed to prevent smoking initiation and promote cessation in this distinct population.

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STUDIES OF CHILDHOOD cancers have provided many important insights regarding the biology, treatment, and late effects of cancers in humans. Advances in cancer therapy during the last several decades have transformed childhood cancers from highly lethal diseases to typically curable conditions. The probability of 5-year survival after diagnosis of a childhood cancer has increased to approximately 72%.[1,2] As a result of this dramatic increase in survival, the priorities of clinicians and researchers have expanded to include the care and management of survivors, ongoing surveillance for detection of adverse late effects, and the identification of high-risk populations for whom prevention and/or intervention strategies can be developed and tested to minimize treatment-related morbidity and mortality. Since childhood cancer survivors have the potential to live a normal life span, serious consideration needs to be given to investigation of the potential impact of lifestyle-related factors on their subsequent health.

The available literature describes the variety of long-term medical effects that can develop and persist among individuals diagnosed and treated for cancer during childhood and adolescence.[3-6] The late effects of cancer or curative treatments include therapy-related second cancer and damage to vital organs, including the cardiovascular, pulmonary, and reproductive systems. Lifestyle factors are known to influence an individual's risk of disease[7-9] and thus may further increase the risk of adverse late effects among cancer survivors. Therefore, preventable tobacco-related cardiac, pulmonary, neoplastic, and other diseases should be a focus for prevention strategies among this susceptible, high-risk population. To assist in developing effective intervention strategies within the Childhood Cancer Survivor Study (CCSS) cohort, we examined smoking behaviors among 5-year survivors of childhood cancer, over the age of 18 years, to evaluate predictors of cigarette smoking initiation and cessation.

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METHODS

In 1993, the Long-Term Follow-Up Study began the enrollment of 21,552 individuals, treated at 25 centers in the United States and Canada (see Appendix), who survived 5 years or more from the diagnosis of cancer, leukemia, tumor, or a similar illness diagnosed during childhood or adolescence. The population presented in this report are derived from the group of 20,304 individuals, referred to as the CCSS, who fulfilled the following eligibility criteria: (a) diagnosis of leukemia, CNS malignancies (all histologies), Hodgkin's disease, non-Hodgkin's lymphoma, kidney cancer, neuroblastoma, soft tissue sarcoma, or malignant bone tumor; (b) diagnosis and initial treatment at one of the 25 collaborating CCSS institutions; (c) diagnosis date between January 1, 1970, and December 31, 1986; (d) age less than 21 years at the time of diagnosis; and (e) survival of at least 5 years from the time of diagnosis, regardless of previous or current disease status. The CCSS was established, through funding from the National Cancer Institute, as a large research resource for studies of childhood cancer survivors. Coordinated by the Department of Pediatrics at the University of Minnesota, the CCSS represents the largest and most comprehensively characterized research cohort of childhood cancer survivors ever assembled in the United States. The CCSS protocol and participant contact documents were reviewed and approved by the institutional review boards at each of the 25 collaborating institutions. Informed consent was obtained from all participants before completion of the baseline questionnaire; additionally, participants signed a separate consent form authorizing the release of medical records of their cancer treatment.

The methods and cohort characteristics for the CCSS are presented in detail elsewhere.[10] Briefly, of the 20,304 individuals eligible for CCSS, 2,996 (14.8%) could not be located after implementing extensive tracing efforts and are thus presently considered lost to follow-up. An additional 3,132 (15.4%) did not participate in the study by completing a baseline questionnaire. Nonparticipants and those lost to follow-up did not, in general, differ from participants with respect to demographic, disease, or treatment characteristics.[10] Since parents were the primary respondents for subjects under 18 years of age, they were omitted from the current analysis to avoid the possibility of inaccurate accounting of previous and current smoking history. Accordingly, the current report is restricted to the information available at the time of the analysis for those 9,709 participants who were over the age of 18 years when completing the baseline survey.

Measures

Medical record abstraction, according to a structured protocol, was conducted at each CCSS center and included detailed information about cancer type, treatments received, and clinical characteristics of the survivor. The 24-page baseline questionnaire, completed by the survivor, provided information on demographics, personal and family medical history, functional limitations, health-related status (eg, physical functioning, chronic illnesses), work history, and living circumstances. The analysis of predictors of smoking initiation and smoking cessation included standard measures of demographics, including race, age, sex, education, household income, marital status, as well as age at time of cancer diagnosis, cancer type, and cancer treatment. Current smokers were defined as those who reported having smoked at least 100 cigarettes in their lifetime and currently smoked on a regular basis. Former smokers were defined as individuals who reported smoking 100 or more cigarettes in their lifetime but did not currently smoke. Never-smokers included those who reported that they had not smoked more than 100 cigarettes in their lifetime. Other variables assessed included age of smoking onset, average number of cigarettes smoked, total number of years smoked, quit attempts, age at cessation for former smokers, and use of tobacco products other than cigarettes.

Data Analysis

Descriptive, univariate statistics were used to evaluate the relationship between smoking status (current smoker, former smoker, and never smoked) and the selected demographic and disease variables. Statistical significance was defined as a P value of less than .05 for a two-sided test. To examine variables associated with smoking incidence, the age at which smoking started was used to determine the total number of person-years before smoking commenced in each subgroup. Individuals classified as never smoked were treated as censored data, with the end point being the date of questionnaire completion. A similar approach was used for quitting smoking, the number of person-years being the difference between the age of starting to smoke and the age at stopping. Participants who were classified as current smokers at questionnaire completion were treated as censored data, with the end point being the date of questionnaire completion. Those classified as having never smoked did not contribute to the smoking cessation analysis. The person-years data were analyzed using Poisson regression to estimate the relative risk (RR).[11] Plots were generated of life-table estimates of cumulative incidence of smoking initiation and of smoking cessation among smokers. Death before smoking initiation/cessation was treated as a competing-risk event.[12] Because specific treatment modalities are known to be associated with an increased risk of cardiac and pulmonary toxicity, we also examined the relationship between smoking status, cancer type, and previous cancer treatment. Specific treatments evaluated included bleomycin, carmustine (BCNU), lomustine (CCNU), anthracyclines, and radiation to the chest and to the spine. Treatment, diagnosis, and demographic characteristics that had a significant effect on smoking status were then examined together in multivariate models for the incidence of starting and quitting smoking. At the time of the current analysis, medical records abstraction was completed for 63% of the study population; therefore, treatment-related analyses were restricted to the 6,139 subjects with available data.

Smoking initiation and cessation rates for the CCSS cohort were compared with data from the National Health Interview Survey (NHIS).[13] The 1993 NHIS survey data were selected because of the temporal relationship with initiation of the CCSS data collection in 1994 and the specific NHIS survey sampling scheme used in that year, which maximized the number of subjects included for smoking-related data. Using expected values standardized by age, sex, and white/nonwhite race, observed to expected (O/E) ratios were computed along with corresponding confidence intervals and P values estimated using Byar's approximation.[10]

RESULTS

Study Population

Demographic characteristics of the CCSS cohort are presented in Table 1. Of the 9,709 participants (age 18 and over), 46% are female, with the median age at the time of study participation being 26 years (range, 18 to 47 years). The majority of the study participants (84%) identified themselves as "white not Hispanic," reflecting the characteristics of the patient populations at the participating study centers. Thirty-eight percent reported being married, 84% had more than a high school education, and 67% reported an

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Table 1. Demographics Among CCSS Cohort Members, Age 18 and Older

	Total Population		Sex				Smoking Status							
			Male		Female		Current Smoker		Former Smoker		Never Smoked		Unknown	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
All persons	9,709	100	5,199	100	4,510	100	1,659	100	1,017	100	6,805	100	228	100
Age														
18-20 years	1,771	18	973	19	798	18	248	15	92	9	1,395	20	36	16
21-24 years	2,344	24	1,246	24	1,098	24	398	24	159	16	1,716	25	71	31
25-29 years	2,598	27	1,460	28	1,138	25	455	27	245	24	1,836	27	62	27
30-34 years	1,823	19	951	18	872	19	344	21	277	27	1,164	17	38	17
35-39 years	872	9	414	8	458	10	155	9	169	17	531	8	17	17
40-49 years	301	3	155	3	146	3	59	4	75	7	163	2	4	2
Race														
White not Hispanic	8,179	84	4,392	84	3,787	84	1,412	85	889	87	5,679	83	199	87
White Hispanic	181	2	79	2	102	2	32	2	21	2	121	2	7	3
Black not Hispanic	381	4	197	4	184	4	47	3	16	2	310	5	8	4
Black Hispanic	13	0	5	0	8	0	2	0	—	—	11	0	—	—
American Indian/Alaska Native	60	1	32	1	28	1	20	1	6	1	34	0	—	—
Asian or Pacific Islander	98	1	60	1	38	1	8	0	9	1	80	1	1	0
Other	357	4	196	4	161	4	58	3	31	3	260	4	8	4
Not specified	440	5	238	5	202	4	80	5	45	4	310	5	5	2
Household income														
Less than $20,000	1,929	20	985	19	944	21	487	29	173	17	1,217	18	52	23
$20,000-$59,999	4,404	45	2,373	46	2,031	45	737	44	502	49	3,074	45	91	40
Over $60,000	2,144	22	1,178	23	966	21	248	15	252	25	1,623	24	21	9
Not specified	1,232	13	663	13	569	13	187	11	90	9	891	13	64	28
Marital status														
Single	4,951	52	2,914	56	2,037	45	642	39	295	29	3,897	57	117	51
Married or living as married	3,632	38	1,716	33	1,916	42	691	42	593	58	2,324	34	24	11
Widowed	11	0	2	0	9	0	2	0	2	0	7	0	—	—
Divorced or separated	723	7	371	7	352	8	254	15	103	10	362	5	4	2
Not specified	392	4	196	4	196	4	70	4	24	2	215	3	83	36
Educational status														
1-12 years (not HS grad)	977	10	600	12	377	8	307	19	72	7	554	8	44	19
Completed high school, post HS	5,531	57	2,987	57	2,544	56	1,000	60	565	56	3,802	56	164	72
College graduate, postgraduate	2,652	27	1,348	26	1,304	29	246	15	315	31	2,087	31	4	2
Not specified	549	6	264	5	285	6	106	6	65	6	362	5	16	7
Cancer diagnosis														
Leukemia	2,836	29	1,465	28	1,371	30	489	29	185	18	2,119	31	43	19
CNS	1,296	13	710	14	586	13	165	10	112	11	991	15	28	12
HD	1,742	18	922	18	820	18	302	18	282	28	1,085	16	73	32
NHL	860	10	611	12	249	6	157	9	90	9	597	9	16	7
Kidney (Wilms)	613	6	278	5	335	7	127	8	66	6	418	6	2	1
Neuroblastoma	374	4	184	4	190	4	77	5	39	4	252	4	6	3
Soft tissue sarcoma	919	9	478	9	441	10	162	10	106	10	632	9	19	8
Bone cancer	1,069	11	551	11	518	11	180	11	137	13	711	10	41	18

Abbreviations: HS, high school; HD, Hodgkin's disease; NHL, non-Hodgkin's lymphoma.

annual household income of $20,000 or more, at the time of the baseline data collection.

Reported Tobacco Use

In total, 9,481 (98%) of the 9,709 survivors sufficiently answered the questions on tobacco use to allow their smoking status to be established. Twenty-eight percent of the study participants reported having been a smoker (ie, smoked at least 100 cigarettes in their lifetime). The actuarial estimated incidence of initiating smoking within the cohort was 32% by 40 years of age (Fig 1). Reported smoking prevalence (ie, current smokers) was 17% overall, 19% in males, and 15% in females; 457 of the smokers reported initiation before the diagnosis of their cancer. The average reported rate of smoking was 14 cigarettes per day (median, 13; range, one to 60). Quit attempts were relatively

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Fig 1. Actuarial estimates of the proportion of individuals who smoked by age at initiation.

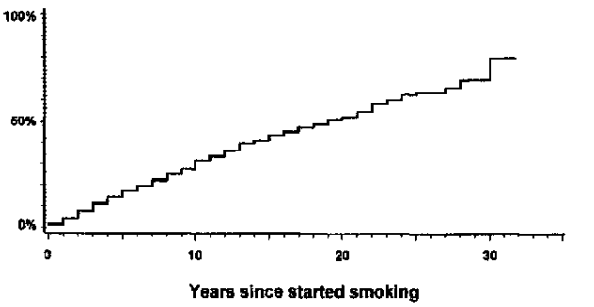

Fig 2. Actuarial estimates of the proportion of smokers who were currently nonsmokers by years since initiation of smoking.

common, with 41.5% of current smokers reporting attempting to quit in the previous 2 years. The actuarial estimated proportion of smokers who had quit within 25 years of initiation was 64% (Fig 2). Former smokers reported being abstinent for an average of 4.8 years (median, 3 years; range, < 1 to 28 years).

It is of interest to note that 11% of the cohort reported using tobacco products other than cigarettes. Almost all of the use was reported by males, with less than 1% of females reporting use of other tobacco products. Among male participants, 6% reported currently using chewing tobacco, 3% snuff, 2% pipes, and 10% cigars. Use of chewing tobacco was most common among males aged 21 to 24 years, while use of cigars was most common among males aged 35 to 39 years. Reported lifetime use of tobacco products for males and females, respectively, was cigarettes (29% and 26%), cigars (10% and < 1%), pipes (2% and < 1%), chewing tobacco (6% and < 1%), and snuff tobacco (3% and < 1%).

Assessment of reported smoking status (ie, cigarette use) and type of prior cancer therapy revealed that the proportion of survivors who ever smoked or were current smokers did not differ substantially according to exposure to treatment modalities known to be associated with cardiac and/or pulmonary complications: bleomycin, BCNU, CCNU, anthracyclines, or radiation to the chest or spine (Table 2). The proportion of survivors reported as ever-smokers was similar among those previously exposed versus not exposed to the pulmonary-toxic chemotherapeutic agents bleomycin (28% *v* 27%) or BCNU/CCNU (22% *v* 27%). The frequencies of smoking were also similar for survivors whether or not they were previously exposed to the cardiotoxic anthracyclines (25% *v* 28%) or therapeutic radiation involving the chest or spine (26% *v* 27%).

Age-, Sex-, and Race-Standardized Smoking Rates

Comparison of the smoking rates for the CCSS cohort over 18 years of age to those for the general population revealed that the frequency of smoking initiation was significantly lower among survivors (O/E ratio, 0.72; 95% confidence limits [CL], 0.69, 0.75) overall, as well as for males (O/E ratio, 0.73; 95% CL, 0.69, 0.77) and for females (O/E, 0.70; 95% CL, 0.66, 0.74). Among cancer survivors who smoked, a larger number had stopped smoking compared with expected (O/E, 1.22, 95% CL, 1.15, 1.30). This higher frequency of smoking cessation was present for both males (O/E, 1.17; 95% CL, 1.07, 1.28) and females (O/E, 1.29; 95% CL, 1.17, 1.41).

Cumulative Incidence of Smoking Onset and Cessation

Analyses were conducted to evaluate the cumulative incidence of smoking by age at initiation within subgroups

Table 2. Frequency of Survivors by Smoking Status and Previous Pulmonary/Cardiac Toxic Therapy

	Bleomycin				BCNU/CCNU				Anthracyclines				Chest Irradiation			
	Yes		No		Yes		No		Yes		No		Yes		No	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Never smoked	329	72	4,154	73	324	78	4,159	73	1,745	75	2,738	72	1,366	74	3,117	73
Ever smoked	125	28	1,531	27	93	22	1,563	27	580	25	1,076	28	485	26	1,171	27
Ever smoked																
Current smoker	73	16	954	17	55	13	972	17	356	15	671	17	285	15	742	17
Former smoker	52	12	577	10	38	9	591	10	224	10	405	11	200	11	429	10

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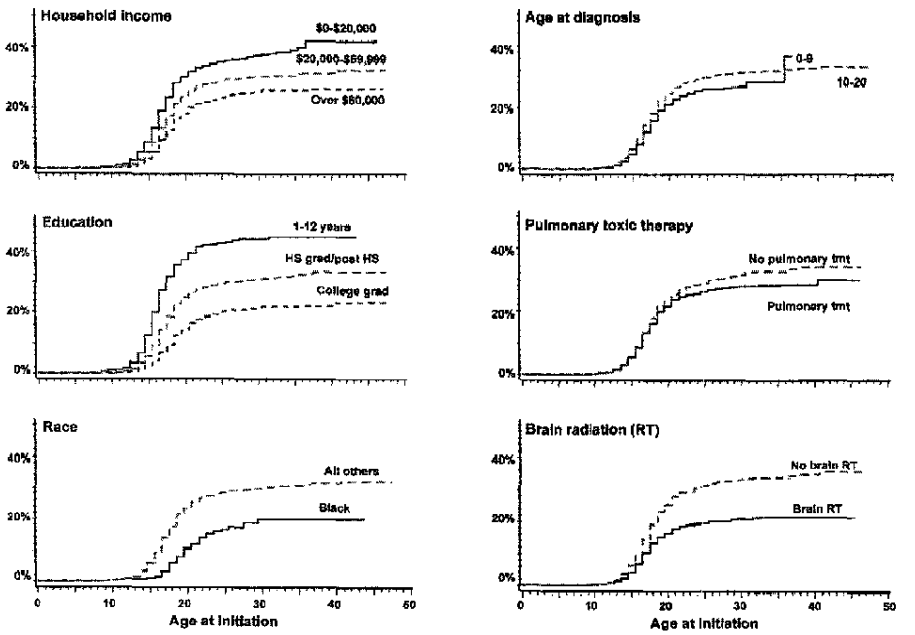

Fig 3. Actuarial estimates of age at initiation of smoking for selected characteristics.

defined by sex, race, age at cancer diagnosis, household income, education, and type of cancer therapy. Provided in Fig 3 are the actuarial estimates for selected characteristics found to be statistically significantly associated with smoking onset. Striking associations exist between smoking onset and socioeconomic factors, including education and income. The actuarial estimated incidence of smoking initiation at 30 years of age for those who were college graduates, high school graduates (with or without some post–high school education), or non–high school graduates was 21%, 31%, and 44%, respectively. The proportion of smokers was significantly smaller among blacks and among those who had received treatment that could potentially have an adverse effect on pulmonary function. The estimated incidence of smoking by age 30 years was 32% for those with an annual household income of less than $20,000 versus 25% for those with an income of over $60,000. A substantial difference existed for cigarette smoking between those who had received radiation therapy to the brain (21% at 30 years of age) and those who had not (33% at 30 years of age). Less striking but still statistically significant (P = .01) is the difference between those treated with pulmonary-toxic therapy (32% at 30 years of age) and those not treated with pulmonary-toxic therapy (28% at 30 years of age).

Summarized in Fig 4 are the actuarial estimates of years to smoking cessation (defined as nonsmokers at the time of the study) among those who smoked. Individuals who did not graduate from high school had a substantially lower estimated rate of quitting compared with college graduates (26% *v* 72%, 20 years after initiation of smoking). It was estimated that only 40% of those who started smoking before the age of 14 years would be nonsmokers 20 years later, compared with 64% of those who started smoking when they were18 years of age or older. Interestingly, while there was a higher rate of smoking observed among those who did not receive brain irradiation, those smokers who did receive radiation therapy to the brain were estimated to be less likely to quit within 20 years (42% nonsmokers) compared with those smokers who did not receive brain irradiation (56% nonsmokers). The significant test for trend revealed a positive correlation between rates of smoking cessation and years of education. Smokers who were diagnosed with cancer before the age of 3 years were significantly more likely to stop smoking than those diagnosed at later ages. Note that age at cancer diagnosis was 0 to 9 years for initiation and 0 to 3 years for cessation; these groupings were significant for each outcome in the multivariate models.

Multivariate Analyses of Factors Related to Smoking Initiation and Cessation

Using results from univariate analyses, a multivariate model was constructed for risk of smoking initiation (Table 3). In the univariate analysis, the following factors were identified to be statistically significantly associated with risk

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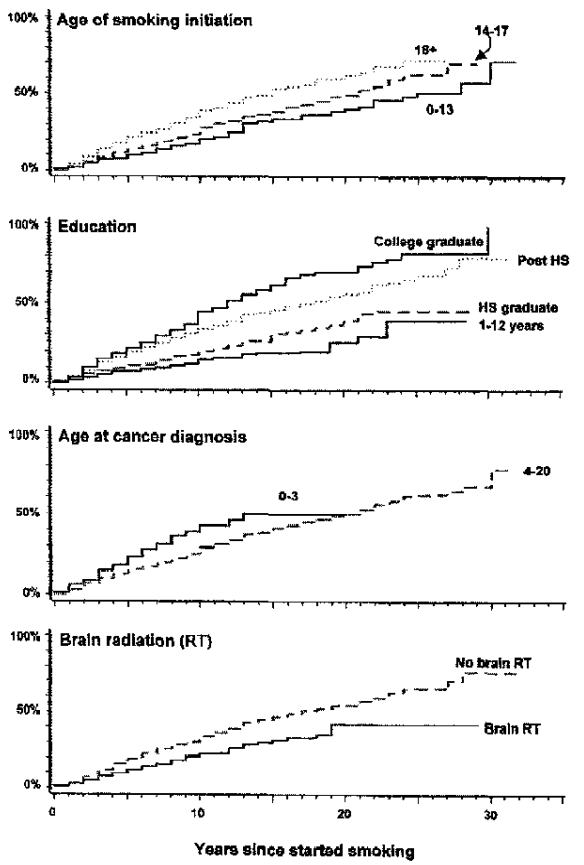

Fig 4. Actuarial estimates of the years to smoking cessation for selected characteristics.

of smoking: sex (male), low household income, low education levels, race (nonblack), cancer diagnosis at age 10 or older, radiation therapy including the brain, and pulmonary-toxic treatment. Sex was not significant when the effects of age at cancer diagnosis, household income, and education were considered and was therefore removed from the final multivariate model. Increased risks independently associated with initiation of cigarette smoking included not having graduated from high school (RR, 2.75), being nonblack (RR, 1.72), and having an annual household income of less than $20,000 (RR, 1.57). Characteristics associated with a decreased risk of smoking initiation included having received radiation therapy involving the brain (RR, 0.61) or pulmonary-toxic treatment (RR, 0.88) and being less than 10 years of age at cancer diagnosis (RR, 0.81).

A similar multivariate approach was applied to evaluate factors associated with smoking cessation among those survivors who reported ever being smokers (Table 4). Univariate analyses identified statistically significantly higher rates of quitting smoking to be associated with sex (female), race (nonblack), household income (positive correlation), age at smoking initiation (positive correlation), level of education (positive correlation), age at cancer diagnosis ($\leq$ 3 years), and not having received radiation to the brain. Sex, race, and household income were not significant when considered together with the other variables and were excluded from the final multivariate model. Age less than 14 years at smoking initiation, not having graduate high school, and having received radiation therapy to the brain were independently associated with a statistically significant increased risk of being a current smoker (RR, 1.67; RR, 3.23; RR, 1.64, respectively); younger age at cancer diagnosis was associated with an increased likelihood of quitting smoking (RR, 0.49).

DISCUSSION

Twenty-eight percent of the CCSS population over 18 years of age reported having been a smoker, with 17% (one in every six) being a current smoker. This is unacceptably high, given that many of these individuals have been exposed to treatments that are known to compromise cardiac, vascular, and/or pulmonary function. An additional cause for concern is that for those cancer survivors who started to smoke, the reported rate of smoking cessation was found to be only modestly greater than that in the general population.

The CCSS collected self-reported data regarding smoking status since biochemical verification in this large and geographically dispersed population was not possible. While some survivors might not have accurately reported their smoking status, any resulting misclassifications would most likely have the effect of underestimating the prevalence of smoking in the cohort. Several studies have addressed rates of self-reported smoking among adult survivors of childhood cancer; it is difficult to compare the data from these studies, however, because of the diversity, and often the small size, of the study populations. Haupt et al[14] reported the frequency of smoking among participants in the Five-Center Study, a project that included 1,289 survivors, diagnosed between 1945 and 1974, with a markedly different distribution of cancer diagnoses from that observed in contemporary survivor populations. They found a very high reported rate of ever smoking (57%), with 28.6% of this group reporting being current smokers. However, these data reflect an era when the social acceptability of smoking was considerably greater, and the prevalence in the population higher, than in recent decades. Compared with sibling controls, survivors in the Five-Center Study population

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Table 3. Multivariate Analysis of Factors Related to Smoking Initiation Among Childhood Cancer Survivors

Characteristic	RR	95% CL		P	
		Lower	Upper	Group	Trend
Household income					
< $20,000	1.57	1.34	1.85	< .001	
$20,000-59,999	1.28	1.11	1.48	< .001	
≥ $60,000	1.00				< .001
Education					
1-11 years	2.75	2.28	3.31	< .001	
High school/some post-HS	1.65	1.46	1.88	< .001	
College graduate	1.00				< .001
Race					
Black	0.58	0.38	0.83	.006	
All other	1.00				
Age at cancer diagnosis					
0-9 years	0.81	0.72	0.91	< .001	
10-20 years	1.00				
Pulmonary-toxic treatment					
Yes	0.88	0.79	0.98	< .001	
No	1.00				
Brain radiation					
Yes	0.61	0.53	0.69	< .001	
No	1.00				

demonstrated an 8% decrease in smoking initiation. A survey of 40 adult long-term survivors of childhood cancer found a smoking prevalence rate of 17.5%.[15] Tao et al,[16] reporting on a series of 592 survivors of childhood acute lymphoblastic leukemia from the Children's Cancer Group (diagnosed from 1970 to 1987), found that 23.0% had ever smoked, compared with 35.7% of sibling controls. This rate is similar to the observed rate of 24% among the 2,836 leukemia survivors in the CCSS cohort.

Previous reports, using siblings as a comparison, have found that cancer survivors who became smokers were not more likely to quit.[14-16] In the CCSS cohort, using age-, sex-, and race-specific rates from the general population for comparison, we observed that survivors were more likely to quit smoking, although the magnitude (O/E ratio, 1.22) does not reflect a dramatic difference. This is cause for serious concern and indicates that increased effort must be aimed at the design, testing, and implementation of directed interven-

Table 4. Multivariate Analysis of Factors Related to Smoking Cessation Among Childhood Cancer Survivors Who Were Current Smokers*

Characteristic	RR	95% CL		P	
		Lower	Upper	Group	Trend
Age at smoking initiation					
0-13 years	1.67	1.23	2.27	.001	
14-17 years	1.32	1.08	1.62	.001	
18+ years	1.00				< .001
Education					
1-11 years	3.23	2.22	4.76	< .001	
High school	2.27	1.72	3.03	< .001	
Some post-high school	1.39	1.12	1.72	.002	
College graduate	1.00				< .001
Age at cancer diagnosis					
0-3 years	0.49	0.38	0.64	< .001	
4-20 years	1.00				
Brain radiation					
Yes	1.64	1.27	2.13	< .001	
No	1.00				

* Eg, risk of being a current smoker among those who started smoking.

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tions. Our results indicate that age at smoking initiation, educational level, age at cancer diagnosis, and brain irradiation are independent predictors of who will continue to smoke and represent possible target populations for focused interventions.

The observed lower overall rate of smoking in the CCSS cohort compared with the general population suggests that survivors are aware, in general, of the risks associated with smoking. However, qualitative research conducted by our team also suggests that they are insufficiently aware of the extent to which these risks may be impacted by their prior treatment-related exposures. This observation is supported by our overall finding that prior exposure to specific cancer treatments known to be associated with compromised pulmonary, cardiac, or vascular function did not seem to substantially influence the frequency of smoking in the cohort. It is notable that a modest reduction in the occurrence of smoking initiation was observed in the multivariate analysis when considering all treatments potentially affecting pulmonary function combined. It may be that inadequate information about the adverse effects of smoking is presented by healthcare providers as part of long-term follow-up for this population, or that childhood cancer survivors are not receptive to such information when it is presented within the follow-up healthcare setting.

The reasons why cancer survivors choose to smoke are not known, but denial and a perception of invulnerability as a result of having conquered cancer have been postulated as possible factors.[17] In the CCSS cohort, the likelihood of smoking initiation was observed to be associated with age at cancer diagnosis, with elevated rates for those diagnosed in adolescence. This suggests that healthcare providers may particularly want to emphasize the importance of not smoking to these individuals. Additional research is needed to determine the optimal strategies for health interventions, including an emphasis on adolescent cancer patients and survivors diagnosed during adolescence.

Interestingly, several of the relationships observed in the CCSS cohort between smoking and demographic variables mirror those in the general population.[18-21] For example, the subgroup of CCSS participants with low income and low education (less than high school) reported smoking rates comparable to their counterparts in the general population. In addition, blacks in the CCSS cohort were significantly less likely to initiate smoking than nonblacks, which likely reflects the lower smoking prevalence found among African-American youth in the general population. The low smoking prevalence among Hispanics is also reflective of national trends, although the sample size for this subgroup was too small to permit separate analyses. Overall, these sociodemographic factors seem to extend their influence on smoking behaviors irrespective of previous or current health status. It is apparent that the survivor population characterized by low education and low income represents a subgroup at greatest risk for future smoking-related events and should also be targeted for interventions.

We observed a reduction in risk of smoking onset among survivors treated with radiation to the brain, a group consisting largely of survivors of CNS malignancies. We speculate that this group of individuals, who suffer more severe treatment-related neurologic and/or neuropsychologic deficits than the overall cohort, may be more likely to live in an environment where the opportunities to start smoking are restricted. Impaired function, which is generally associated with a younger age at diagnosis, may also impact the decreased likelihood of smoking cessation in this population. Because the CCSS population is large and diverse, it was possible to undertake numerous comparisons. Therefore, the possibility exists that some of the unexpected associations observed to be statistically significant may be the result of multiple comparisons and require confirmation in other studies.

The data generated from the large CCSS cohort of childhood cancer survivors provide important insights into the smoking behaviors of this unique population. The observed smoking rate of 17% reinforces the need for continued follow-up of the cohort to document and quantify the impact of smoking on the health status of survivors. Moreover, a clear imperative exists to increase our understanding of the predictors of smoking initiation and cessation and to develop and test effective smoking interventions. As an initial project, we are currently conducting a study in the CCSS population to test the effectiveness of a peer-based counseling approach to smoking cessation.

All healthcare providers involved in the diagnosis, treatment, and/or long-term care of childhood cancer patients have a responsibility to assist the members of this high-risk population in making healthy lifestyle choices, including the choice to quit, to reduce, or to not start smoking. This responsibility will increasingly fall to the pediatricians, internists, family practice physicians, gynecologists, and others who will manage the long-term care of these individuals as they grow older. The beneficial impact of even very brief physician-delivered counseling on smoking cessation is well-documented[22]; thus, it is important that all healthcare providers understand the importance of working with their patients who are survivors of cancer to reduce the use of tobacco products.

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APPENDIX

The appendix listing CCSS institution and investigators is available online at www.jco.org.

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